

Special subject on very high cycle fatigue

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In the applications of aircrafts, automobiles, railways, biomedicine and off-shore structures, many components may experience cyclic loading conditions over a long period of time, running up to several hundred million cycles.¹ Determination of long life fatigue behavior becomes extremely important for better understanding and design of components and structures. There is a growing interest in investigation of very high cycle fatigue behavior (10^7 – 10^{10} cycles) and very low crack growth rates (10^{-12} – 10^{-9} m/cycle) in various materials.^{1–8} This is called very high cycle fatigue (VHCF).

Most engineering designs have hitherto been based on the assumption that ferrous materials exhibit a fatigue limit and for any cyclic stress below this value, they are unaffected and endure infinite life. Recent studies^{4–8} however point out the fact that most materials including ferrous alloys experience failure up to 10^9 cycles and above and that this phenomenon of VHCF is a result of subsurface or internal crack initiation, at the defect sites in materials. Hence, there is a growing understanding that a safe-life design based on the infinite-life criterion does not exist anymore, at least for some materials. These materials exhibit a continuously decreasing stress – life response, even at a great number of cycles (10^6 – 10^9). Hence for these materials, the fatigue strength at a given number of cycles is an important term instead of endurance limit. There is a strong need to investigate the fatigue behaviours of structural materials in the VHCF regime nowadays.⁴

VHCF has assumed great significance in recent years particularly after it has been established that a fatigue limit does not exist in many cases. However, the current fatigue code design curves are developed on the basis of data for fatigue life of less than 10^6 – 10^7 cycles, far below the 10^9 – 10^{12} cycles experienced in the industries which require super-long service life.^{5–7} It is well

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known that nonmetallic inclusions are usually presented in all commercial steels as a result of the steel making process. Being invariably, the sites for fatigue crack nucleation, the inclusions play a crucial role in governing the fatigue lives of high strength steels. While low cycle fatigue of steels usually involves fatigue crack initiation from inclusions/defects on the surface of the specimen, in the VHCF regime, the defects located within the specimen become favorable sites for crack initiation.¹⁻⁸ The occurrence of internal cracking has been clearly observed in many materials containing inclusions/defects. However, the mechanism of fatigue cracking at the inclusion sites still has not been fully understood. It is also believed that fatigue fracture does not initiate from inclusions below a critical size.

The objective of this special subject is to offer readers a concentration understanding on VHCF. With this subject we will also celebrate two upcoming conferences, the 23rd International Congress of Theoretical and Applied Mechanics (ICTAM2012) to be held in Beijing, China, August 19-24, 2012, and the 6th International Conference on Very High Cycle Fatigue (VHCF6) to be held in Chengdu, China, 2014.

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